FOUNDRY CASTING MATERIAL COMPOSITION

INTRODUCTION

[0001] The present invention relates to a composition and method of using foundry casting materials for improved removal after casting.

[0002] In the foundry industry, one of the procedures used for making metal parts is by casting. Casting materials are arranged to create an assembly forming a mold or receptacle having an empty cavity that can be filled with a molten metal. Typically, such a cavity is defined by an outer mold boundary (a boundary defining a surface perimeter or spatial limit of the mold shape) formed by an outer shell mold, and further, by cores that may optionally be placed within the interior of the cavity for additional interior surface contours defined by inner mold boundaries. As referred to herein, "mold" refers to any mold component including a core or shell that is formed from casting material that forms a cast part. Cores are solid components that provide hollow internal elements within a cast metal part, without necessitating the need for additional machining or boring. Shells form the exterior components of the mold cavity. Any remaining empty spaces within the cavity form the shape of a part, having both the inner and outer surfaces once the molten metal solidifies. After molten metal is poured into the assembly of molds and cores, it is left to cool and form a metal part which is subsequently removed from the assembly.

[0003] Different portions of the mold may be sacrificial, meaning that the mold is only used once in the casting process and then destroyed after

casting the part. Generally, sacrificial components include the inner cores, and sometimes the outer shell molds. Such an example of the outer shells being sacrificed is in investment casting, where the entire shell mold is destroyed. Further contemplated are shells where layers that contact the metal surface are often sacrificed, and then the shell is reconstituted with another new external replacement layer.

[0004] Casting materials also contain a binder system, typically comprising a binder material and a compatible solvent suspension system for holding the foundry sand within a solid matrix. When a mixture of casting materials is formed, it must be further treated to solidify the casting material, which is generally achieved by cross-linking or curing the binder in the matrix. Specific binder materials dictate the type of treatment necessary to solidify the structural mold. No-bake, cold-box, and hot-box all refer to the types of treatment necessary for solidification. Hot-box treatment includes pre-heating (e.g. from temperatures ranging from about 40°C to about 260°C) the casting material mixture with a thermosetting binder for to cure or set. Cold-box treatment is where curing is typically achieved by a vapor or gas catalyst passed through the casting material mixture, which induces curing, sometimes conducted at slightly elevated temperatures (e.g. from about 35°C to about 100°C) to ensure vaporization of the catalyst. The casting material mixture is shaped by putting it into a pattern and allowing it to cure until it is self-supporting and can be handled. A no-bake system cures without any baking (i.e. at ambient temperatures) where a catalyst is added directly to the casting material mixture.

Usually, a no-bake catalyst is admixed with the casting material mixture and then formed into a shaped mold where it subsequently sets up as a solid.

[0005] After the metal has cooled within the casting material assembly, the exterior mold is readily removed. However, the casting material cores that remain on the inside of the cast part are difficult to remove. Known methods of removing such cores include immersing the steel casting into a bath of molten salt at elevated temperatures (e.g., about 500°C) for many hours. Often, after removing the part from the molten bath, casting material still adheres to the surface of the metal part, and must be removed by physical means such as blasting, chipping, or drilling the debris away by hand. Such removal methods are frequently dangerous and inefficient.

[0006] Recently, attempts have been made to remove the remaining casting materials by immersing the cast part (with cores present) into an electrolytic bath, where an anode is submerged into an electrolyte and the surface of the part forms the cathode. Hydrogen gas bubbles are formed at the surface of the metal part, which are thought to assist in removing adherent casting materials. However, it has been found that electrolytic activity and hydrogen bubble formation may not be effective in removing casting materials from the metal part. Thus, there is a need for easy and efficient removal of a sacrificial casting material remaining within or on a cast part, preferably by electrolytic processing.

SUMMARY

[0007] The present invention provides foundry casting materials for use in making a mold for a cast part, comprising a foundry sand, a binder, and a disintegration additive. In various embodiments, the present invention provides a foundry mold formed for the casting of a part, comprising a mixture of a foundry sand, a binder, and a disintegration additive, where the mixture is treated to form a solid.

[0008] According to the present invention, methods of forming a metal part are provided. Such a method comprises pouring molten metal into a mold, where the mold is formed of a material comprising foundry sand, binder, and a disintegration additive. The molten metal is cooled to form a solid, and the solid is removed from the mold.

[0009] Further embodiments according to the present invention include a method of removing residual casting material from a metal part, where the method comprises the steps of: attaching the metal part having residual casting material to a power source having a first and a second electrode of opposite polarities, wherein the first electrode is attached to the metal part. The metal part is contacted with an electrolyte that is in contact with the second electrode. Current is generated through the electrolyte, from the first electrode to the second electrode. The residual casting material is made from a mixture comprising casting sand, binder and a disintegration additive.

[0010] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be

understood that the detailed description and specific examples, while indicating specific embodiments of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 depicts an exemplary apparatus useful in a cleaning method of this invention.

[0012] Figure 2 depicts a second exemplary apparatus useful in a cleaning method of this invention.

[0013] It should be noted that the apparatus depicted in Figures 1 and 2 are intended to show the general characteristics of apparatus and methods among those of this invention, for the purpose of the description of such embodiments herein. These figures may not precisely reflect the characteristics of any given embodiment, and are not necessarily intended to define or limit specific embodiments within the scope of this invention.

DESCRIPTION

[0014] The present invention provides a disintegration additive for a casting material that facilitates enhanced removal of any residual casting material remaining on or in a cast part. The foundry casting material is formed into at least a portion of a mold, preferably a sacrificial portion of the mold (e.g. shell,. core, or both) remaining within or on a cast part after the casting is completed. The foundry casting material comprises a foundry sand, a binder, and a disintegration additive. In certain embodiments, the foundry casting material is

treated to form a solid foundry mold. One embodiment of the present invention includes a method of removing any residual casting material from a metal part by attaching the metal part having residual casting material to one electrode of a power source having electrodes of opposite polarities and contacting the metal part with an electrolyte, accomplishing electrolytic processing. (As used herein, the word "include," and its variants, is intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that may also be useful in the materials, compositions, devices, and methods of this invention. Also, as used herein, the words "preferred" and "preferably" refer to embodiments of the invention that afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful and is not intended to exclude other embodiments from the scope of the invention.

[0015] Based upon the large variety of casting applications, foundry casting molds (e.g. cores and shells) may be constructed of the same or different materials. Selection of casting materials used for the shell molds depends upon various factors, including the physical and chemical properties of the metals to be cast. The melting point of the metal or metal alloy dictates temperature and strength requirements of the mold. Other factors in casting material selection include: the intricacy of the shape being cast, finish needed, and tolerance for flaws and defects.

[0016] Conventional casting materials typically contain an aggregate, such as a conventional foundry sand, generally being either bank or synthetic sands. Bank sands are naturally occurring and usually contain contaminants (e.g. clay). Synthetic sands (e.g. lake sands or sharp sands) are formed with a base sand grain, which is typically silica, but may also be zircon, olivine, or chromite. Sand selection in a casting material is dependent on the application. Various physical and chemical properties (including grain size and distribution) effect interaction with the binder material and specific metals being cast. A casting material may further include mixtures of different sands, including both synthetic and bank sands.

[0017] Further, casting materials contain a binder which can be no-bake, cold-box, or hot-box, as previously discussed. A phenolic urethane binder is preferred for both the no-bake and cold-box processes. The difference in the curing method of phenolic urethane binder originates from the different solvents (or binder system) in which the binder is dispersed. In a no-bake, a different solvent is used which reacts with a liquid curing catalyst that is mixed with the casting material mixture (including an aggregate and binder system) to form a mold mix. The liquid catalyst is mixed into the casting material mixture before shaping and cures within a short time thereafter (e.g. from about 30 minutes to about a few hours later). In a cold-box process, a gaseous tertiary amine curing catalyst (e.g. TEA (tetraethylamine) and DMEA (dimethylethylamine)) is passed through a shaped casting material mixture containing a phenolic urethane binder (typically consisting of a phenolic resin component and a polyisocyanate

component) to cure the mixture. Phenolic urethane binders are widely used in the foundry industry to bond the sand cores used in casting iron and aluminum.

[0018] Hot-box fabrication processes use resins that harden the sand when the casting material is pre-heated to temperatures between from about 35° to about 300°C. Such an example of hot-box fabrication includes shell molding, where the shell is formed from a mixture of sand and a thermosetting resin binder that is placed against a heated metal pattern, or template. The heat induces setting of the resin, forming a solid forming at least a portion of the receptacle for receiving molten metal and forming a cast metal part. Such resins may include binders based upon furan resins and furfuryl alcohols. Typically, such resins are cured in the presence of a latent acid curing catalyst. Ceramic mold mediums are another example of hot-box treated mold, wherein the inorganic clay components (e.g. aluminum silicate, bentonite, or montmorillonite) form a binder. They are typically formed by layering a lost wax/foam mold with successive layers of a slurry of foundry sand and inorganic binder which are then cured with heat.

[0019] The present invention provides a foundry casting material which comprises a mixture comprising a foundry sand, a binder, and a disintegration additive. The additive (herein "disintegration additive") for the casting material compositions facilitates and/or expedites removal of any residual casting material from a metal part formed using the casting material. Preferably, the disintegration additive facilitates removal of the casting material by causing the casting material to disintegrate, in whole or in part, by either heating, chemical (or

electrochemical) interaction, or use of moderate physical force. One such method of applying both electrochemical interaction and moderate physical force is with an electrolytic cleaning method. By "disintegration", it is meant that the casting material is broken down into smaller particulate form, in pieces small enough that the original solid form is readily removable from any substrate or hollow on or within the cast part. The present invention also provides a foundry mold formed for the casting of a part, comprising a mixture of a foundry sand, a binder, and a disintegration additive, where the mixture is treated to form a solid (e.g. a mold to accept the molten metal).

[0020] Selection of disintegration additives to compositions of the present invention is dependent on the metal being cast, but generally should not compromise the characteristics necessary for proper casting, including surface finish and tensile strength. The additive preferably does not significantly impair structural strength or heat endurance, which could potentially induce premature failure during the casting process. Further, the additive is preferably selected for chemical compatibility with the binder resin, most particularly with either the polymeric body, side chains, or terminal groups to promote homogeneous distribution to achieve proper curing strengths. Grain size and distribution for an additive may also be important aspects depending on the metal to be cast, to avoid marring or other defects in the surface of the finished part. Thus, some of the primary considerations in additive selection include physical and chemical compatibility within the casting material matrix and interaction with the metal to be cast. Secondary considerations include selecting a disintegration additive that

is available on a widespread basis in a large variety of grain sizes and purity for low cost.

[0021] A preferred embodiment of the present invention includes disintegration additive compounds that are crystalline solids and have relatively high melting points (i.e. above 300°C). In one embodiment, polar molecules are preferred. In one embodiment, the disintegration additive enhances the electron/ion conduction of the casting material when contacted with a polar electrolyte (e.g. water). In various embodiments, disintegration additives are selected from a class of salts that volatilize during casting of the metal part leaving behind a porous and slightly unstable structure. In various embodiments, the disintegration additive is chosen to facilitate ion mobility within the casting material solid structure, resulting in chemical interaction with an electrolyte that reduces electrolytic processing time, which sufficiently disintegrates the solids remaining on the cast part.

[0022] One preferred embodiment of the present invention includes a disintegration additive that is a salt. Salts fulfill many of the physical, chemical, and economic requirements needed for a disintegration additive. Preferred salts selected as additives include salts that are inorganic and soluble in water, and preferably comprise cations having metals selected from Groups I and II of the Periodic Table. As referred to herein, "Group" refers to the Group numbers (i.e., columns) of the Periodic Table as defined in the current IUPAC Periodic Table. Preferred anions for the salt of the disintegration additives according to the present invention include, carbonates, nitrates, sulfates, phosphates, hydroxides,

and halogens. Certain preferred salts according to the present invention comprise cations of sodium, potassium, calcium, ammonium, or magnesium, and include salts, such as for example: sodium carbonate, sodium bicarbonate, sodium chloride, sodium hydroxide, sodium iodide, sodium nitrate, sodium phosphate, disodium phosphate, sodium sulfate, potassium carbonate, potassium chloride, potassium hydroxide, potassium iodide, potassium nitrate, potassium phosphate, potassium sulfate, calcium carbonate, calcium chloride, calcium hydroxide, calcium iodide, calcium nitrate, calcium sulfate, ammonium sulfate, ammonium carbonate, magnesium carbonate, magnesium chloride, magnesium hydroxide, magnesium iodide, magnesium nitrate, magnesium phosphate, magnesium sulfate, and equivalents and mixtures thereof. In a preferred embodiment, the disintegration additive is selected from the group consisting of sodium chloride, potassium chloride, sodium carbonate, sodium bicarbonate, sodium phosphate, and mixtures thereof. In a particularly preferred embodiment, the disintegration additive comprises sodium chloride. In another preferred embodiment, the disintegration additive comprises sodium bicarbonate, disodium phosphate, and mixtures thereof. In another preferred embodiment, the disintegration additive comprises sodium carbonate, disodium phosphate, and mixtures thereof.

[0023] One aspect of a preferred embodiment of the present invention relates to a method of making of a mold made from a casting material of this invention. Thus, in certain preferred embodiments the present invention provides a foundry mold for the casting of a part comprising a mixture of a foundry sand, a

binder, and a disintegration additive, where the mixture is treated to form a solid. In one aspect of the present invention, the disintegration additive and foundry sand raw materials may be pre-mixed to achieve homogeneous distribution, prior to adding the binder materials. In some casting material molds, the shape of the form is created with the foundry sand and disintegration additive, prior to adding the binder materials. In other preferred embodiments of the present invention, the foundry sand, disintegration additive, and binder material are admixed together concurrently to form an admixture and later shaped. Any mixing of the raw materials is done by conventional mixing means known to one of skill in the art until the raw materials are evenly distributed. Examples of such conventional mixing means include: zero-retention high speed continuous mixers, low-speed augur-type continuous mixers, and batch mixers.

[0024] The admixture of casting materials is shaped in any variety of ways known to one of skill in the art, typically achieved by using a pattern in the shape of the portion of the surface of the part to be cast. The casting materials surround the pattern and form a contrapositive surface contour, or shape, within the casting materials, which creates the mold shape or receptacle which will later hold molten metal. By "contrapositive" it is meant that a first surface has a general shape or contour and that the first surface interfaces with a second surface and generally imprints a matching or opposite contour along the second surface where the first and second surface interface. Patterns may be fabricated from wood, metal, or other materials, including wax (known as a "lost-wax" process in investment casting), where casting materials coat the pattern by

dipping the wax pattern into a slurry of casting materials that forms individual layers. Other variations include depressing the pattern into a bed of casting material which adopts the shape of the pattern. Many variations of forming casting materials into molds are known by skilled artisans and are dependent upon the type of casting materials used. (e.g. silica sand molds, lost wax ceramic molds, and the like)

[0025] Cores are solid pieces formed from casting materials having contoured surfaces that will form part of the interior shape of the cast part, hence forming inner mold boundaries within the cast part. The surfaces of the cores and molds are contoured to impart a contrapositive surface contour onto the molten metal which coats the interior cavities of the casting mold. Thus, solid components forming the casting mold include both the exterior shell molds and the interior cores, and both may incorporate aspects of the present invention. The mixture is then shaped into a contoured surface and treated to form a rigid solid having a contoured surface.

[0026] After creating the casting mold components, any individual casting mold components are arranged into a mold having an outer mold boundary formed by the outer shell molds which defines the external surface of the cast metal part and an inner boundary formed by the inner shell molds which creates internal surfaces of the cast metal part. The empty portions or cavities are then completely filled with enough molten metal to contact all surfaces of the casting mold creating a shaped cast metal part. Typically, a casting mold further contains a sprue, a runner, and a riser to allow for pouring of the molten metal

into the empty cavity of the casting mold. The sprue receives the incoming molten metal and channels it below to the casting mold cavity, the runner is region that connects the sprue to various areas within the casting mold, and the riser is an additional reservoir that provides extra metal to the casting mold cavity during solidification when the metal contracts in size. Thus, molten metal is poured into the casting mold and then permitted to solidify into the cast metal part. The present invention is particularly useful for forming industrial parts, which are conventionally formed by metal casting. Manufactured industrial parts, such as cast metallic components, may include, for example, automotive drive train components (e.g. a combustion engine blocks).

[0027] After solidification of the metal, the cast solid part is removed from the outer shell. If the casting mold was formed of two shell parts, they are separated and the cast solid part is easily removed. Generally, the outer shell is readily removed from the cast part after solidification. Sometimes, layers of the outer shell may remain on the cast metal substrate, or surface. These layers must be subsequently removed from the surface of the cast part. Generally, the difficulty in cleaning a cast part arises when removing the inner core components. The inner cores remain within the cast part after solidification, and the conventional means of removal include those previously mentioned, the energy intensive process of submersing the part in a molten salt bath at relatively high temperatures or by physical removal of the core by blasting, chipping, or sanding away the residual casting material, and usually using both processes.

[0028] Thus, the present invention thus provides a method of forming a metal part, which comprises pouring molten metal into a mold formed of a material comprising a foundry sand, a binder, and a disintegration additive, then cooling the molten metal to form a solid, and removing the solid from the mold.

[0029] The present invention also provides an alternate preferred embodiment where residual casting material is removed from a metal part. The metal part having residual casting material is attached to a power source having a first and a second electrode of opposite polarities, where the first electrode is attached to the metal part. The metal part is contacted with an electrolyte, where the electrolyte is in contact with the second electrode. Current is generated by the power source through the electrolyte, from the first electrode and second electrode. In this manner, a method of electrolytically cleaning the residual material from the metal part is provided.

[0030] Industrial parts washers among those useful herein comprise, in one embodiment, one or more processing zones for washing, rinsing, drying and other steps for cleaning industrial parts. A conveyor typically transports the parts through the processing zones from one end of the washer to the other. Industrial parts washers typically spray the parts with heated liquid cleaners, and thus most washers include an enclosure to capture the spray and contaminants being washed. Certain preferred industrial parts washers may include a holder to secure and support the part to be washed. In one embodiment, the holder is suitable for holding an automotive drive train components. The holder and part are enclosed in a chamber which forms a sealed unit encapsulating the part. A

cleaner dispersing system is operable to remove residual materials from the part. A preferred part washer useful herein is described in U.S. Patent Application Serial No. ______________, "Housingless Part Washer," Stockert et al.; filed August 21, 2003, incorporated by reference herein.

[0031] In one embodiment, the cleaner dispersing system comprises a spray device, such as a spray head or nozzle, which is coupled to a cleaning fluid supply. The spray device is positioned within the chamber, such that it is operable to contact the part with cleaning fluid. It is preferred that such a parts washer additionally comprises a fluid recirculator which collects and recycles spent or used cleaning fluid. The cleaning fluid supply is contained in a cleaning fluid tank, and is connected to a fluid propulsion device. Such devices include those known to one of skill in the art, such as a centrifugal pump, where a pressurized cleaning fluid supply is delivered to a spray device. In certain alternate preferred configurations, a parts washer comprises a reservoir filled with cleaning fluid which immerses the part on the holder. Such parts washers may further be adapted to incorporate electrolytic cleaning, where the spray device(s) are connected to a power source with a first electrode having a first polarity, and the holder is connected to a second electrode having a second polarity of the same power source. In this manner, the part is charged with opposite polarity to the spray device. Further, the cleaning fluid becomes charged and operates as an electrolyte.

[0032] As shown in Figure 1, the present invention provides methods for removing any residual casting material from a cast metal part 10 with an

electrolytic processing apparatus 12, by contacting the cast metal part 10 having the inner core 22 (intact) with an electrolyte 16. In one embodiment, the cast metal part 10 is submerged in an electrolyte 16, and serves as a cathode 23. The cast metal part when attached to the negative lead 26 of a power source 20. At least one anode 18 is attached to a positive lead 24 of the power source 20 is also placed within the electrolyte 16. When a voltage is applied by the power source 20, current is generated through the electrolyte 16 between the anode 18 and the cathode 23.

[0033] One aspect of the present invention includes a disintegration additive 28 in the casting material inner core 22 that facilitates disintegration when subjected to electrolytic processing. This type of disintegration additive preferably promotes electron/ion conduction. Other preferred types of disintegration additives include those substances with a boiling point below the temperature of the molten metal, which permits volatilization of the salt from the casting material core or mold. The resulting void spaces create a porous structure that enhances disintegration. The disintegration additive may comprise mixtures of disintegration additives, each of which facilitate disintegration in a different manner. One preferred embodiment of the present invention is an apparatus comprising a holder adapted to secure a cast metal part, and a cleaner dispersing system operable to remove residual casting material from the cast metal part, where the casting material is made using a disintegration additive.

[0034] In another preferred embodiment, the present invention provides an apparatus comprising a cast part having a surface coated with residual casting material comprising a disintegration additive, a holder adapted to secure the cast part, and a fluid tank adapted to contain cleaning fluid for cleaning the cast part. Additionally, the apparatus may comprise a fluid propulsion device connected to the fluid tank. A spray device is connected to the propulsion device which is adapted to apply cleaning fluid on a surface of the cast part. The apparatus is operable to remove residual casting material form the metal part. Another preferred embodiment of the present invention provides a system for the production of a clean industrial part, comprising a casting material suitable for casting a part. The casting material comprises foundry sand, binder, and disintegration additive, where in a portion of the casting material remains on the part after casting. A parts washer is operable to contact the cast part with cleaning fluid.

[0035] Other preferred embodiments of the present invention include a method of making a clean metal part, comprising casting a metal part using a mold formed using a casting material comprising foundry sand, binder, and a disintegration additive, and cleaning the cast metal part using a parts washer comprising a cleaner dispensing system. In certain preferred embodiments, the parts washer comprises at least one spray device operable to apply cleaning fluid on a surface of the cast metal part.

[0036] In one embodiment, the cleaning fluid comprises an electrolyte. Such electrolyte cleaning fluids may be formed, for example, by dissolving

disodium phosphate and sodium bicarbonate in water. The metal part having a casting core or residual material on a surface is contacted with the electrolyte. The remaining casting material comprises foundry sand, binder, and a disintegration additive. The cast metal part is connected to a negative terminal of a power source and an anode is connected to a positive terminal of the power source and placed in the electrolyte. A current is generated through the electrolyte via the power source to remove the casting core from the cast metal part. In preferred embodiments, at least one inner core is removed from the conductive solid by generating current between the anode and conductive solid through the electrolyte, whereby the inner core at least partially disintegrates.

[0037] In another embodiment of the present invention, a generalized parts washer is shown in Figure 2, where a continuous stream or spray 30 of electrolyte 16 is sprayed on the cast metal part 10 having an inner core 22 (with a disintegration additive 28) from at least one anode 18 (i.e. spray device) which is connected to a positive lead 24 of the power source 20. The cast metal part 10 is secured by a holder 25 which is connected to the negative lead 26 of the power source 20 which conducts electricity and forms the cathode 23. Further, the electrolyte spray 30 may be directed to residual casting materials 32 left on the surface 34 of the cast metal part 10. Such electrolytic action assists in disintegrating the inner core 22 or residual material 32 so that they may be readily removed to produce a clean cast metal part 10. Variations of preferred embodiments of the present invention include anodes 18 that spray electrolyte

16, while submerged in a reservoir of electrolyte, to increase the electrolytic action.

[0038] Preferred electrolytes comprise conductive salts, and may form both basic and acidic solutions when dissolved in a solvent, such as water. Salts useful herein include disodium phosphate (Na_2HPO_4), sodium bicarbonate ($NaHCO_3$), sodium carbonate (Na_2CO_3), and mixtures thereof. Voltage is applied by a conventional power source, as known to one of skill in the art, such as for example, a low voltage direct current source with 5 to 350 A output from a 60 HZ, 230V, 3 phase alternating current source. Electrolytic cleaning processes among those useful herein include those disclosed in United States Patent No. 6,203,691 and 6,264,823 both to Hoffman, Jr., et al, incorporated herein by reference.

[0039] After submerging the conductive part in the electrolyte and applying the power to generate current, the part is left within the electrolytic processing until all of the inner cores erode or disintegrate and are flushed away from the cast part. Such flushing away from the part generally occurs from turbulent electrolyte flow, where the particulate is removed from the part. The above process also removes layers of residual shell material from the substrate of the cast part, when the casting material is prepared according to the present invention. The pieces of particulate that are formed by disintegration of the casting material may be collected from the bottom of the electrolyte container and recycled to form new casting raw materials, if feasible, as previously discussed, in a fluid recirculator.

[0040] Thus, one method of removing a casting core includes forming an electrolyte by dissolving electrolyte salts in water. Then, the electrolyte contacts the metal part (with the casting core made of foundry sand, binder, and disintegration additive intact). The cast metal part is then connected to a negative terminal of a power source, and further an anode connected to a positive terminal of the power source is placed in the electrolyte. The power source is activated and generates current through the electrolyte to remove the casting core from the cast metal part. Thus, variations of this method may be used to form a clean cast metal part.

[0041] The embodiments described herein are exemplary and not intended to be limiting in describing the full scope of compositions and methods of this invention. Equivalent changes, modifications and variations of specific embodiments, materials, compositions and methods may be made with substantially similar results.